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Seasonal dynamics of herbaceous species along the topographic gradients under different conservation regimes of Kashmir Himalaya

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Abstract
The present investigation entitled "Seasonal dynamics of herbaceous species along the topographical gradients under different conservation regimes of Kashmir Himalaya" was carried out in two protected areas viz., Dachigam National Park (DNP) and Overa-Aru Wildlife Sanctuary (OAWS) along with their adjoining unprotected areas in Srinagar and Anantnag districts of Kashmir valley during the year 2014-15 & 2015-16, respectively, with the aim to evaluate phytosociology and its dynamics in different seasons of protected and unprotected areas. These research objectives centered on two major goals, to assess the performance of protected areas and to study the feasibility of incorporation of adjoining unprotected areas. On the basis of different aspects, each protected and unprotected area was divided was into north and south aspects. Each aspect was further sub divided into three different altitudinal ranges viz., A_1 (1600-2100m), A_2 (2100-2600m) and A_3 (2600-3100m) covering different forests of protected as well as unprotected areas. 1x1m sample plots in each altitudinal range on different aspects of protected and unprotected areas were laid out to study the structural and functional parameters of herbs. The vegetation was studied across three different seasons. The results revealed that density (tillers/m^2), basal area (cm^2/m^2) and frequency (%) of herbaceous vegetation in each protected and unprotected areas increased from spring till summer and decreased thereafter. Among the seasons, summer recorded the maximum density, basal area and biomass, followed by spring and autumn, whereas, middle altitude and north aspect exhibited the highest values among different altitudinal ranges and aspects, respectively. The study concluded that performance of protected areas was better as compared to unprotected areas and upper altitude unprotected areas (A_2 & A_3) on both north and south aspect are in a position to be merged with respective protected areas in future.

Keywords: Protected area, dachigam national park, oveara-aru wild life sanctuary, phytosiology

Introduction

The inquisitiveness for shrinking biodiversity, as a result of increasing knowledge of interdependent ecosystems and scientific research establishing the new vistas of the uses of flora and fauna, is global. Mankind has realized the importance of biodiversity and its implications in the foundation and sustenance of life, concepts like sustainable development, biodiversity conservation, maintenance of gene pools, etc. have become sources of universal concern. This inquisitiveness has in turn led to the designation of special areas purely for sustainable conservation, in the case of developed as well as developing countries, known as Protected Areas [PA_S] (Rucha and Hussain, 2003) [33]. Protected area is thus defined as an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means (IUCN, 1999) [17]. These areas are assumed to guard forest from alterations and are recognized to maintain carbon sinks, protect biodiversity, and to help stabilize global climate (Munroe *et al.* 2007) [32]. Protected areas have been the principal defense of habitat, and will carry on playing the role in conserving the biodiversity especially the species with extreme threat (Gaston *et al.* 2008) [13]. They are known for their ability to serve as safe havens for species including ecological balance, which otherwise is difficult to achieve in intensely managed natural landscapes as well as providing room for natural evolution and possible ecological restoration (Dudley *et al.* 2010) [10]. It is therefore vital to understand the contribution which this system actually makes to biological conservation.

Since protected areas signify the foundation of global conservation efforts, garnering support for such conservation areas will need the robust social and economic ideas to stimulate the political support for an adaptive action (Balmford *et al.* 2003) [3]. International treaties call for the conservation of biodiversity in all its manifestations. Conservation efforts have focused on maintaining biodiversity through establishment of networks of protected areas. Main goal of Japan conference on protected areas network specifically identifies the need to expand the number and area of protected areas to at least 17% of terrestrial protected areas. There are numerous ways to study the biodiversity; these include inventory and documentation, diversity assessment, population status and ecology, management and threat. Along with vegetation type distribution, topographic variability, climatic gradients and biotic pressure, criteria of biodiversity inventory also forms the cornerstone in conservation planning and strategies. Apart from such advantages these areas can be helpful in representing can be effective at representing additional aspects of biodiversity, such as ecological uniqueness, species distributions, species diversity and contiguous intact natural habitats (Wessels *et al.* 1999) [44]. Any spatial and temporal changes in habitats are first observed in the vegetation. Vegetation classification and mapping currently are the most important tools for studying varying ecological sysytems and helping in easing out the interrelated complexity both in spatial as well as temporal aspects of (Mucina and Rutherford, 2006) [31]. The essential attributes of of forest ecosystem like, species composition, structure and function are reflected in response to environmental as well anthropogenic variables (Shaheen *et al.* 2012; Bisht and Bhat, 2013) [37, 6]. Protected areas are answer to the overall biodiversity loss (Jenkins and Joppa 2009) [19].

Material and Method

The present investigation was carried out during the years 2014-15 and 2015-16. The physical and environmental attributes of study area, materials used and methodology adopted for the study are given below:

Study Area

The study was conducted in two protected areas viz. Dachigam National Park and Overa-Aru Wildlife Sanctuary. Dachigam National Park lies between 34º 05′ N-34º 11′ N longitude and 74º 54′ E-75º 09′ E latitude and the area comes under the civil jurisdictions of Srinagar, Anantnag and Pulwama districts. Its area comes in 2.38.12 (Himalayan Highlands) bio geographical province, and 2A Bio-geographic zone. It is 21 km north east to Srinagar, the summer capital of Jammu and Kashmir State situated in Zabarwan mountain range of Great Himalayas. The total area of Dachigam national Park is 141 sq. km. Dachigam National Park is divided in two zones Lower and Upper Dachigam. Dachigam National Park is known world-wide because it holds one of the best populations of Asiatic black bear in Asia and the red deer sub species Hangul. Dachigam occupies almost half of the catchment zone of the famous Dal Lake and is the main source of water for the Srinagar city. The park is foster mother nurturing rich assets of threatened as well as rare flora and fauna. Dachigam national park with adjacent conservation reserves and wildlife Sanctuaries makes Greater Dachigam Landscape which harbors high level of biodiversity. The natural boundaries to the park are two steep mountain ridges, one originating from Harwan water reservoir on the south west side of the park and the other originating from Dara/Khimber side with an elevation gradient of 2,600 to 3,000m. Dachigam is bounded by Sindh valley to the north east, Tarsar, Lidderwath, Kolhai of Lidder Valley and Overa-Aru Wildlife Sanctuary in the East, Tral range in the south east and Harwan, Brain and Nishat in the west and south-west (Kurt, 1978) [24]. As per revised Champion and Seth (1968) [8], the vegetation of Dachigam National Park is typically Himalayan moist temperate forest, sub-alpine forest and alpine forest type and can be classified into following forest types:

- Moist temperate deciduous forest
- *Parrotia* (pohu) scrub forest
- West Himalayan low level blue pine forest
- Western mixed coniferous forest
- Deciduous alpine scrub

Keeping in view floral diversity among protected, the present study was undertaken to throw light on floristic variation in two different aspects along altitudinal gradient by investigating forests (Champion and Seth, 1968) [8] located at different elevations as follows (Table 1).

Table 1: Forest area selected for vegetation and carbon stock estimation analysis

S. No	Protected/Unprotected area	District	Aspect	Altitudinal ranges (m) in each aspect
1	Dachigam National Park (DNP)	Srinagar Anantnag Pulwama	North and South	A_1=1600-2100 A_2=2100-2600 A_3=2600-3100
2	Adjacent unprotected area Dachigam National Park (UDNP)	Srinagar Anantnag Pulwama	North and South	A_1=1600-2100 A_2=2100-2600 A_3=2600-3100

Climate

The climate in Dachigam is sub-Mediterranean type with bixeric regime having two spells of dryness of April-June and September-November. The area observes an irregular weather conditions with a considerable variation in the amount of precipitation. Snow is the main source of precipitation and in some parts melts till June. Dachigam National Park has a temperate climate with cool summer and chilling winter. The relative humidity is generally low in most part of the year.

Vegetation analysis

Fifteen sample plots of size 1x1m in square shape were laid out in each altitudinal range of north and south aspects in both protected and unprotected areas of Dachigam National Park and Over-Aru Wildlife Sanctuary. Sample plots were selected following simple random sampling using lottery method. Same methodology was repeated over three different seasons.

Observations recorded

Density (D)

It represents the population of a species in the community and was calculated by counting number of each species in the sample plot/quadrat.

Frequency

It is the indicator of number of samples in which the given species occurs, thus expresses the distribution of various species in the community, Frequency was calculated by using the formula following:

$$\text{Frequency (\%)} = \frac{\text{No. of sample in which the species occurred}}{\text{No. of sampling units studied}} \times 100$$

Basal area

The cross sectional area of herbs falling in the recording unit was determined by the formulae as:

$$\text{Basal area} = \pi \frac{d^2}{4}$$

Where,
d = Diameter in linear units

Importance value index (IVI)

It is a measure of how dominant a species is in a given forest area. It is a standard tool used to inventorize a forest. For each species in different quadrates relative density (RD), relative basal area (RBA) and relative frequency (RF) were calculated by following Misra (1969): [30]

$$RD = \frac{\text{Density of a species}}{\text{Total density of all species in quadrat}} \times 100$$

$$RBA = \frac{\text{Basal area of species}}{\text{Total basal area of all species in a quadrat}} \times 100$$

$$RF = \frac{\text{Frequency of a species}}{\text{Total frequency of all species in a quadrat}} \times 100$$

The importance value index (IVI) for each species was worked out by using formula given by Curtis and Mcintosh (1950): [9]
IVI=Relative density + Relative basal area + Relative frequency the methodology was followed during three different seasons of the year viz., spring, summer and autumn. Observations were recorded in each month of a season.
Design of survey: Stratified random sampling

Experimental Results

Phytosociology of Herbage

Density (tillers/m^2) and basal area (cm^2/m^2) of herbage increased gradually from spring to summer and declined in autumn. The combined contribution of forbs, legumes and sedges to both phytosociological attributes of herbage was less in comparison to grasses in all the sampling seasons during the study period. The details of phytosociological parameters are presented below:

Summary of density (tillers/m^2) of herbaceous vegetation

Data pertaining to mean density of herbage in different forests of protected and unprotected sites of Dachigam National Park and Overa-Aru Wildlife Sanctuary showed maximum values (493.00) in sites of Dachigam National Park on north aspect in summer season followed by sites of Overa Aru Wildlife Sanctuary on north aspect in summer season (404.00). The lowest (97.00) density were for unprotected sites of Dachigam National Park at upper altitude (A_3) on south aspect in autumn season, followed by unprotected sites of Overa-Aru Wildlife Sanctuary (97.60) at upper altitude (A_3) on north aspect in autumn season.
Among the seasons maximum (206.85) density was found in summer followed by spring (169.52) and autumn (165.35) whereas, maximum (209.81) density in different altitudes were found at middle altitude (A_2) followed by upper altitude (A_3) (171.18) and lower altitude (A_1) (160.74), respectively.
The density for different aspects of protected and unprotected sites Dachigam National Park and Overa-Aru Wildlife Sanctuary revealed maximum (189.96) density for north aspect of protected sites Dachigam National Park followed by south aspect of Overa-Aru Wildlife Sanctuary with (171.20). Maximum density among protected and unprotected sites of Dachigam National Park and Overa-Aru Wildlife Sanctuary were recorded to be 199.42 and 161.73, respectively (Table 2).

Summary of basal area (cm^2/m^2) of herbaceous vegetation

Data pertaining to mean basal area of herbage in different forests of protected and unprotected sites of Dachigam National Park and Overa-Aru Wildlife Sanctuary revealed maximum (41.22) basal area in protected sites of Dachigam National Park at A_2 on north aspect in summer season followed by A_1 on same aspect (39.39), whereas, the lowest basal area (2.96) were reported for unprotected sites of Dachigam National Park at upper altitude (A_3) on south aspect in autumn season followed by (3.07) for unprotected sites of Overa-Aru Wildlife Sanctuary at upper altitude (A_3) on north aspect in autumn season.

Table 2: Density (tillers/m^2) of herbaceous vegetation

Districts Sites			D_1							D_2							Overall Mean	Factor Mean
			A_1		A_2		A_3		Sub-mean	A_1		A_2		A_3		Sub-mean		
			N	S	N	S	N	S		N	S	N	S	N	S			
Sites	P_1	S_1	119.40	186.80	201.60	172.00	153.60	156.80	165.03	115.20	158.80	172.80	162.40	139.60	138.60	147.90	156.46	A_1=160.74
		S_2	264.20	307.20	493.00	348.80	324.20	288.80	337.70	216.60	237.00	404.00	277.60	271.40	255.60	277.03	307.36	A_2=209.81
		S_3	123.80	143.80	192.00	153.60	121.60	124.40	143.20	114.60	108.80	166.40	138.60	108.40	117.40	125.70	134.45	
	Sub-mean		169.13	212.60	295.53	224.80	199.80	190.00	215.31	148.80	168.20	247.73	192.86	173.13	170.53	183.54	199.42	A_3=171.18
	P_2	S_1	112.60	111.00	131.20	131.60	134.60	117.60	123.10	114.00	137.60	133.40	131.20	119.60	130.60	129.07	126.08	
		S_2	229.20	221.80	289.20	291.20	261.80	238.60	255.30	207.20	201.40	256.60	250.80	228.80	241.00	233.40	244.35	S_1=169.52
		S_3	107.80	102.20	141.40	143.40	100.80	97.00	115.43	112.20	104.80	124.00	128.80	97.60	109.80	114.13	114.78	
	Sub-mean		149.87	145.00	187.27	188.73	165.73	151.07	164.61	144.47	147.93	171.33	170.27	148.67	170.53	158.87	161.73	S_2=206.85
Overall mean			159.52	178.86	241.40	206.76	182.76	170.53	189.96	146.63	158.06	209.53	181.56	160.90	170.53	171.20	180.58	S_3=165.35
C. D ($P \leq 0.05\%$)																		
District (D)			6.33	D×a	NS	D×P	NS	D×a×P	12.67	D×S	NS	D×a×S	15.52	D×P×S	15.52	D×a×P×S	NS	
Altitude (A)			7.76	A×a	10.97	A×P	NS	A×a×P	15.52	A×S	13.44	A×a×S	19.01	A×P×S	19.01	A×a×P×S	26.88	
D×A			NS	D×A×a	NS	D×A×P	NS	D×A×A×P	NS	D×A×S	NS	D×A×a×S	NS	D×A×P×S	NS	D×A×a×P×S	NS	
Aspect (a)			6.33	Sites (P)	6.33	a×P	8.96	Seasons (S)	7.76	a×S	10.97	P×S	10.97	a×P×S	15.52			

Among the seasons maximum (12.93) basal area were found in summer followed by autumn (8.17) and spring (8.07), whereas, maximum (11.56) basal area in different altitudes were found at A_2 followed by A_1 **(**9.06) and A_3 (8.55), respectively.

The basal area for different aspects of protected and unprotected sites Dachigam National Park and Overa-Aru Wildlife Sanctuary revealed maximum (9.87) basal area for north aspect of protected sites Dachigam National Park followed by north aspect of Overa-Aru Wildlife Sanctuary with (9.58). Maximum basal area for density among protected and unprotected sites of Dachigam National Park and Overa-Aru Wildlife Sanctuary revealed 12.56 and 6.91, respectively (Table 3).

Frequency (%) of herbaceous vegetation

Data pertaining to mean frequency of herbage in different forests of protected and unprotected sites of Dachigam National Park and Overa-Aru Wildlife Sanctuary depicted that maximum (67.00) frequency was recorded in protected sites of Dachigam National Park at A_2 on north aspect in summer season followed by at A_2 (52.40) on north aspect aspect in summer season of protected site of Overa-Aru Wildlife Sanctuary. The lowest (12.00) frequency value were for recortded in protected sites of Overa-Aru Wildlife Sanctuary at upper altitude (A_1) on north aspect in spring season followed by (13.40) in protected sites of Dachigam National Park at lower altitude A_1 on north aspect in autumn season.

Among the seasons, highest frequency were found in summer (31.59) followed by autumn (26.77) and spring (26.06), whereas, maximum (33.40) frequency in different altitudes were found at A_2 followed by A_3 (30.15) and A_1 (20.87), respectively. The frequency for north aspect of protected and unprotected sites of Dachigam National Park revealed maximum (39.07) frequency at A_2 of Dachigam National Park followed by (32.23) at A_2 of Overa-Aru Wildlife Sanctuary. Similarly, frequency for south aspect of protected and unprotected sites of Overa-Aru Wildlife Sanctuary revealed maximum frequency (33.53) for south aspect at A_3 of Overa-Aru Wildlife Sanctuary followed (33.53) at A_3 (Table 4).

Maximum values for frequency among protected and unprotected sites of Dachigam National Park and Overa-Aru Wildlife Sanctuary were observed to be 30.19 and 26.09, respectively.

Table 3: Basal area (cm^2/m^2) of herbaceous vegetation

Districts Sites			D$_1$							D$_2$							Overall Mean	Factor Mean
			A$_1$		A$_2$		A$_3$		Sub-mean	A$_1$		A$_2$		A$_3$		Sub-mean		
			N	S	N	S	N	S		N	S	N	S	N	S			
Sites	P$_1$	S$_1$	12.93	5.78	12.87	6.13	9.27	4.96	8.66	12.42	5.57	11.97	5.86	9.26	5.75	8.47	8.56	
		S$_2$	39.39	9.01	41.22	11.37	26.00	9.69	22.78	33.97	8.37	34.29	11.42	24.05	11.16	20.54	21.66	A$_2$=11.56
		S$_3$	14.45	4.57	12.02	5.64	6.19	4.26	7.86	13.30	4.11	8.02	5.60	5.74	4.89	6.94		A$_3$=8.55
	Sub-mean		22.26	6.45	22.04	7.71	13.82	6.30	13.10	6.02	8.02	23.13	5.60	8.64	6.02	11.99	12.54	
	P$_2$		3.99	2.96	7.90	3.62	4.73	3.69	4.48	3.95	3.95	7.00	5.29	3.71	7.36	5.21	4.85	S$_1$=8.07
		S$_2$	7.54	5.13	20.32	8.68	12.58	8.29	10.42	7.23	6.16	17.85	8.67	10.71	14.23	10.81	10.62	S$_2$=12.93
		S$_3$	3.56	2.54	11.47	4.36	4.56	3.63	5.02	3.07	3.56	10.28	5.57	4.14	6.34	5.49		
	Sub-mean		5.03	3.54	13.23	5.55	7.29	5.20	6.64	4.75	4.56	11.71	6.51	6.19	9.31	7.17	6.91	S$_3$=8.17
Overall mean			13.64	5.00	17.63	6.63	10.56	5.75	9.87	12.32	5.29	14.90	7.36	9.58	8.29	9.58	9.73	
C. D ($P\leq$0.05%)																		
District (D)			NS	D×a	0.66	D×P	NS	D×a×P	NS	D×S	NS	D×a×S	1.14	D×P×S	1.14	D×a×P×S	1.62	
Altitude (A)			0.57	A×a	0.81	A×P	0.81	A×a×P	NS	A×S	NS	A×a×S	1.40	A×P×S	1.40	A×a×P×S	1.98	
D×A			0.81	D×A×a	NS	D×A×P	NS	D×A×a×P	NS	D×A×S	NS	D×A×a×S	NS	D×A×P×S	NS	D×A×a×P×S	NS	
Aspect (a)			0.46	Sites (P)	0.46	a×P	0.66	Seasons (S)	0.57	a×S	0.81	P×S	0.81	a×P×S	1.14			

Table 4: Frequency (%) of herbaceous vegetation

Districts Sites			D$_1$							D$_2$							Overall Mean	Factor Mean
			A$_1$		A$_2$		A$_3$		Sub-mean	A$_1$		A$_2$		A$_3$		Sub-mean		
			N	S	N	S	N	S		N	S	N	S	N	S			
Sites	P$_1$	S$_1$	13.40	22.80	30.00	24.60	24.00	25.00	23.30	12.00	21.00	25.40	26.60	24.00	27.40	22.73	23.02	A$_1$=20.87
		S$_2$	31.80	36.40	67.00	44.00	48.80	44.40	45.40	26.20	31.60	52.40	36.80	44.00	44.60	39.27	42.33	A$_2$=33.40
		S$_3$	19.40	22.20	40.40	27.60	24.20	24.20	26.33	16.20	19.40	33.00	26.60	22.40	27.20	24.13	25.23	
	Sub-mean		21.53	27.13	45.80	32.07	32.33	31.20	33.71	18.13	24.00	36.93	30.00	30.13	18.13	28.71	30.19	A$_3$=30.15
	P$_2$	S$_1$	14.40	13.40	25.20	25.00	21.80	19.00	35.13	18.20	19.60	24.60	25.60	22.40	28.80	23.20	21.50	S$_1$=26.06
		S$_2$	23.20	22.00	42.60	43.80	39.80	39.40	21.33	25.60	26.80	33.80	36.40	38.00	45.80	34.40	34.77	
		S$_3$	14.80	14.40	29.20	29.20	21.00	19.40	23.30	17.80	18.40	24.20	27.80	20.60	27.40	22.70	22.02	S$_2$=31.59
	Sub-mean		17.47	16.60	32.33	32.67	27.53	25.93	25.42	20.53	21.60	27.53	29.93	27.00	20.53	26.77	26.09	S$_3$=26.77
Overall mean			19.50	21.87	39.07	32.37	29.93	28.57	29.56	19.33	22.80	32.23	29.97	28.57	33.53	27.74	28.14	
C. D (P≤0.05%)																		
District (D)			0.78	D×a	NS	D×P	NS	D×a×P	1.57	D×S	NS	D×a×S	1.92	D×P×S	1.92	D×a×P×S	2.72	
Altitude (A)			0.96	A×a	NS	A×P	1.36	A×a×P	1.92	A×S	1.66	A×a×S	2.35	A×P×S	2.35	A×a×P×S	3.33	
D×A			1.36	D×A×a	NS	D×A×P	NS	D×A×a×P	2.72	D×A×S	NS	D×A×a×S	NS	D×A×P×S	NS	D×A×a×P×S	NS	
Aspect (a)			NS	Sites (P)	NS	a×P	1.11	Seasons (S)	0.96	a×S	1.36	P×S	1.36	a×P×S	1.92			

Discussion

Growth parameters of the herbage in forests varied along the altitude and sites. Growth attributes i.e. density (plants/m^2) and basal area (cm^2/m^2) of herbage showed consistent rise from the onset of spring with advancement of growing season, attained peak values in summer season, and decreased thereafter. This prompted sporadic germination and development of herbage with the onset of growth season in spring, the density and basal area of herbage peaked in summer which can be ascribed to congenial growth conditions in terms of nutrient availability, soil moisture, humidity and temperature. Similar pattern of variations in density and basal area of herbage along growing season has been reported by Singh and Yadava (1974) [39], Gupta *et al.* (2000) [14], Ferraz *et al.* (2007) [12], Kunhikannan (2008) [23], Mahmoud (2009) [26], Semwal *et al.* (2008) [35], Kukshal *et al.* (2009) [22], Masoodi (2010) [28], Kharkwal & Rawat (2010) [21], Sharma (2012) [38] and Bhat (2013) [5] for different herbage communities in forests.

Further this variation can be related to difference in the overstorey trees (species and their density) resulting in microclimate modification (Anderson *et al.* 1968; Alaback and Herman, 1988; Thomas *et al.* 1999) [2, 1, 42] and microhabitat changes (Johnson, 1995, Berg and Staaf, 1981) [20, 4] caused by change in environmental variables along the altitude and amount of litter deposition on soil surface that is mainly determined by balance between litter production and amount of litter decomposition rate (Staelens *et al.* 2003) [40] which may be influenced by tree density (Lebret *et al.* 2001) [25], site type (Facelli and Pickett, 1991) [11] and climate characteristics (Bray and Gorham, 1964) [7]. Seeds under litter are deprived of light and cannot root easily (Hamrick and Lee, 1987; Facelli and Picket, 1991; Ellsworth *et al.* 2004) [16, 11] as they differ in their ability to penetrate litter (Sydes and Grimes, 1981) [41] thus fail to germinate many times. Plant exudates released into the soil on decomposition in the form of allelochemicals also play a great role in regulating vegetation patterns, distribution of plants in the community and growth & development of associate species (Saxena and Sharma, 1996) beside inhibiting germination of seeds (Gupta *et al.* 2007) [15]. There are reports about allelochemical production in many woody species, from boreal conifer forests (Mallik, 2003) [27] to tropical forests (McKey *et al.* 1978) [29], temperate forests (Willianson *et al.* 1992) [45] and sub-desert communities (Van Rooyen *et al.* 2004) [43]. Altitudinal variation in herbage growth in forests has been reported by Jamwal and Uniyal (2008) [18], Sevgi and Tecimen (2008) [36] and Sharma (2012) [38].

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